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RESIDENTIAL VENTILATION

SYMPOSIUM

CMHC, OCTOBER 18, 1990

RESIDENTIAL VENTILATION
VENTILATION SYMPOSIUM
October 18th, 1990

Prepared for:

Canada Mortgage and Housing Corporation

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Canada Mortgage and Housing Corporation, the Federal Government's housing agency is responsible for administering the National Housing Act

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APPENDIX A - SPEAKERS NOTES

A) Introduction:

This paper reports on a symposium which was held on October 18th, 1990 at CMHC offices on Montreal Road.

The purpose of the symposium was to provide input, background and resources to the members of the CHBA Ventilation Task Group.

B) Attendees:

Richard Linde	Halifax	Regrets
Chris Mattock	Vancouver	Consultant
Daniel Forest	Drummondville	Venmar Inc, Manufacturer
Rob Dumont	Saskatoon	SRC Researcher
Bruce Clemenson	Toronto	Builder
Gary Proskiw	Winnipeg	Consultant
Mark Riley	Ottawa	Regrets
Frank Szadowski	Ottawa	EMR
Tom Hamlin	Ottawa	CMHC Research
Mike Freedman	Ottawa	HVAC Contractor
Marcel Lemieux	Ottawa	Regrets
John Shaw	Ottawa	NRC-IRC
Ross Monsour	Ottawa	CHBA
Robin Sinha	Ottawa	CMHC Project Implementation
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A) Test-Application:

Some systems and methods need to be introduced as early as possible to the market on a limited scale so that the bugs can be worked out in time for industry-wide application at a later date. Some people refer to this as "chicken-testing".

1) The recommendation to simplify the F326 ventilation training courses arises out of experience gathered during the past two years of course delivery. This is a valuable insight gained from "chicken testing" the method.

2) Some items which are in need of "Chicken Testing" are;

   i) make-up air duct heaters

   ii) powered make-up air devices

   iii) non-powered make-up air devices

   iv) house differential pressure controllers.

3) The existence of a subsidized product testing facility for HRV's resulted in much more rapid product development, with higher qualitative results than would otherwise have been the case. The stimulation of, rather than the reduction of, competition among manufacturers is one of the mechanisms involved.

   In areas where product improvement is required this should be the stimulation method of choice.

B) Technology Development:

Some equipment and systems need to be developed which are not yet ready for limited market introduction. Some of these are:

1) Low-cost, low-maintenance, self-balancing HRV's and ventilation systems.

2) Novel ventilation systems.

3) Simple low-cost methods for field evaluation of ventilation compliance.

4) Diffusers capable of introducing low-temperature air comfortably into a space.

5) High-efficiency, low pressure-drop diffusers

6) Make-up air devices for single and multi-family residences.

7) Portable systems for measuring ventilation effectiveness and compliance.

8) Techniques for increasing ventilation effectiveness.

C) F326

1) The F326 training program needs to be simplified.

i) Although the standard itself is complex (to the lay person) it's application can be quite simple.

ii) Course simplification may be realized through emphasis of on-site tests. (Such tests require development).

iii) "Look-up" charts should be used as much as possible.

iv) More general courses may be required for non-designers, builders and inspection authorities.

2) With respect to the provisions of F326 with respect to house negative pressures and combustion product spillage:

i) The standard disallows many arrangements which are now "standard". Some of the arrangements which have been proposed in order to meet the requirements of F326 may not be well accepted by the consuming public and/or are not practical.

ii) The standard recognizes that there are pre-existing problems with respect to combustion spillage and will assist in ameliorating those problems. In particular the training process which goes along with implementation of such a standard will transfer problem-solving skills to local service personnel.

iii) The standard F326 should be viewed as part of the solution to existing problems of combustion spillage.

D) Education:

1) A change in general societal attitudes is required so that the importance of ventilation is generally recognized.

It is believed that if the public was more aware of the negative implications of poor ventilation, actual attitudes would change.

2) There should be an effort to educate children as to the benefits of good ventilation.

3) The use of high-efficiency furnace blower motors should be encouraged

4) Builders should have access to people who have the skills to fix the problems which they are now and will be confronting such as combustion spillage. Industry training is required to provide these people.

E) Research:

1) There should be a broadening of existing ventilation research to include epidemiological study of respiratory diseases.

2) Study the relationship between house depressurization and radon/soil-gas entry.

3) Study occupant satisfaction and IAQ:

i) Answer the question; What is the best way to sell ventilation?

4) Study the ventilation market:

i) What markets are more receptive to upgraded ventilation; The "greying" market?

ii) What methods are best employed to reach these sectors; Personal Testimonial?

iii) What is the state of the market for advanced ventilation systems ? Can industry statistics regarding the number of HRV's produced be published?

F) Standards:

1) Develop protocols for field measurements of ventilation system performance.

2) Develop product rating standards for high-pollutant source building products.

3) Develop affordable low pollutant housing guidelines for "sensitive" (not hyper-sensitive) individuals.

4) 50 Pa. is to be considered a minimum rating point for fans, 25 Pa. is too low.

5) If a noise criteria is set as a requirement, it must be set in conjunction with a pressure-rating for airflow.

6) The necessity of a performance certification program for bath and kitchen fans should be considered.

7) The necessity of a performance certification program for HRV's should be considered.

Purpose of the CHBA Ventilation Task Force

Bruce Clemenson

A) The purpose of the CHBA Ventilation Task Force is to carry out the following tasks:

1) Research status check

2) Identify builder concerns

3) Identify further research

4) Develop a public position for CHBA with respect to ventilation

B) What criteria does CHBA base it's position on?

1) Health and safety at the best possible price.

2) Any change in present codes must be based on technologies that are reliable and proven in the field. This is in the interest of small builders who are an important segment of CHBA.

3) Builders will accept change if it is done in a reliable way.

A) Tobacco Smoke is the largest indoor Pollution Hazard

35% of the adult population still smokes

B) Formaldehyde is the subject of the most studies;

1) Georgia Pacific Corporation is currently the subject of a substantial lawsuit [with respect to it's liability for the formaldehyde given off by products which it manufactured and which were used in the construction of a house].

2) 0.006 ppm is the approximate background level (outdoors)

3) 0.1 ppm is the HWC (Health and Welfare Canada) maximum acceptable long-term exposure guideline. However, the target level is 0.05 ppm for longer term.

4) Formaldehyde occurs because of off-gassing from construction materials and house-hold furnishings and from tobacco smoke. The reaction of water vapour with the material which off-gasses is part of the mechanism.

5) There is no Canadian standard for off-gassing [of formaldehyde] from particleboard.

6) The decay over time of the off-gas sources is not that fast and the mechanism is tied up with the %RH

7) There is a correlation between formaldehyde levels and ventilation rate, but it is not linear.

8) New buildings may need more ventilation [to control high initial formaldehyde levels and other pollutants]

9) R-2000 houses have quite good formaldehyde levels; significantly better than conventional homes of the same vintage. Early R-2000 homes had higher levels but this improved with the installation of better ventilation systems, and reduced particle board.

10) From the 200 homes survey[1]; 15% of Canadian homes are over 0.1 ppm [of formaldehyde]

C) Pollutants, Other:

1) Humidity;

i) Health studies suggest that 30% is a minimum level for health reasons.

ii) Actual RH levels in northern and dry climate areas in winter are often below 30%.

2) There are 60,000 different chemicals which are in active use, a large number of which may be of concern.

i) The likelihood that a particular chemical has established test procedures and exposure guidelines may have as much to do with the ease of testing for the substance as it's toxicity.

ii) In order to quantitatively assess the larger body of compounds, a measure of "Total Volatile Organic Compunds" (VOC) has been developed.

iii) The measure is simply by weight, no attempt is made to define irritant and benign compounds.

iv) A cigarette smoker, for example, gives off VOC's at rate of 20 mg/hr

v) Current studies suggest that a total VOC level of 0.2 mg/m^3 is a good target for acceptable IAQ.

vi) Wet-process photo-copiers and mothballs have been identified as high-rate sources of VOC's.

3) Health and Welfare Canda (HWC) has established a Federal-Provincial committee which has set exposure guidelines for approximately 20 pollutants.

The guidelines are expressed as "short term" and "long term" maximum exposure levels.

4) There is some confusion with regard to acceptable exposure levels for some basic pollutants. For example Carbon Dioxide;

   i) HWC long-term guideline is 3500 ppm - this is a safety guideline

   ii) ASHRAE long-term guideline is 1,000 ppm - this is a comfort guideline and is often used to guage ventilation rates and ventilation effectiveness.

   iii) Outdoor levels are about 350 ppm

   and Radon.....

   iv) EPA (USA) guidelines are: 4 pci/L
   v) Swedish guidelines are: 2 pci/L
   vi) HWC guidelines are: 22 pci/L

   (1 pci/L is said to carry the health risk which is equivalent to smoking one cigarette per day)

5) Carbon Dioxide:

   i) Levels are good indicators of lack of ventilation. In the commercial setting CO_2 is easy to measure.

   ii) A reliable CO_2 sensor costs $2,000 to $3,000 so it is not a viable control strategy for residential ventilation at this time.

D) Ventilation Rates:

1) Ole Fanger (Denmark) has identified the rate of pollutants given off by one person (body-odour, etc) as one "olf"

   i) Fanger's studies conclude that a rate of 8 L/s/olf is required in order to achieve a dissatisfied rate of about 17%.

   ii) The satisfaction rate used is rather severe because it is for persons entering the space, not persons who have been in the space for an extended period of time.

   iii) a person exhales about 0.17 L/s at roughly 40,000 ppm CO_2

2) With respect to pollutants generated by the building and not the occupants, Fanger suggests that an off-gassing rate of 0.3 olf/m^2 is an average for a group of Danish buildings that he had measured.

3) Ventilation Rates that are in current use are;

   i) ASHRAE 8-10 L/s per person in non-smoking areas, 30 L/s smoking per person in smoking areas.

   ii) F326 - 5 L/s per room/10 L/s for master bederoom and basement. This yields an average of 12 L/s per person(based on 4 persons per house and about 50 L/s/house)

4) Pollutant concentration is a function of:

   i) generation rate
   ii) contamination level of ventilation air
   iii) Ventilation Rate
   iv) Ventilation effectiveness factor

   v) If mixing is "perfect", a ventilation effectiveness factor of 1.0 may be used.

   vi) High ventilation effectiveness with the benefit of reduced rates has been claimed in some Scandanavian ventilation systems which use "displacement" or "plug-flow" ventilation distribution systems.
   These types of systems are for commercial occupancies and may not be applicable to the residential situation.

5) Contamination of intake air is a significant problem in commercial occupancies.
   In residential occupancies, the primary example of this is the entry of wood-stove smoke during temperature inversions.

E) Low-Tox Houses;

1) There are only about 5 truly low-tox houses built in Canada per year. There is a growing body of knowledge which has been developed by persons such as Bruce Small, Greg Allen and Oliver Drerup.

2) "Low-tox" house construction usually includes the following;

i) no particleboard
ii) no plywood
iii) no latex paint
iv) no wallpaper
v) no concrete additives
vi) ceramic tile in plain mortar beds
vii) high efficiency filtration
viii) no combustion sources in the home
ix) usually plaster walls
x) In general, low off-gassing materials for construction materials, furnishings and household cleaning products

F) Needs:

1) Product off-gassing data should be available for the products that we buy.

2) Better sensor technology; CO_2 sensors are too pricey.

3) Low off-gas products need to be available for those who need them (low-tox homes).

G) Conclusions:

1) The 1989 Airtightness Survey indicated that passive ventilation would not be adequate for most new houses in Canada

2) The R-2000 results indicate that properly installed ventilation systems can do the job of controlling indoor air quality in almost all new houses. However, avoiding known emitting materials such as particle boards is also strongly advised.

3) The R-2000 program also demonstrated that ventilation systems must be tested at start-up in order to be effective.

4) Hypersensitive individuals need houses that have even lower air pollution levels than even the R-2000.

5) There is virtually no quantitative information of practical value available on the off-gassing levels of common building materials (e.g. paints particleboard, flooring materials, gypsum board, wall paper, concrete additives, interior grade plywood).

REFERENCES

1. 1989 Survey of Air-tightness of 200 Merchant-built Detached Houses; CMHC, IRC EMR, CHBA.

A) Continuous ventilation is required because there are no sensors available which are capable of measuring the full range of pollutants of concern (up to 60,000 chemicals).

B) Reliable CO_2 sensors with continuous ouptputs cost $2,000 to $3,000 each at the present time.

C) Some work has been done with occupation-adaptive ventilation systems which turn on or off ventilation based on the signal from infra-red motion detectors.
The detectors themselves are not particularly costly (about $20 each) and the installed system can also function as an alarm system.
There are problems associated with field of view and the lack of motion occurring in bedrooms.

D) Source-control is a valid objective but no information as to the actual off-gassing properties of materials are available.

E) For "extra-sensitive" persons the best policy is simple avoidance of those materials which are known to have a high rate of off-gassing.

F) If source-strengths were known, actual ventilation <u>capacity</u>(i.e maximum flow rate) reductions below those which are being put in place may not be realizable. What could be reduced, however is the actual operating <u>rate</u> of the systems.

G) In the near-term, source-control as it relates to chemical emissions from building materials does not have any meaning for the broad housing market. It does have meaning for individuals who are more sensitive than the general population, and in the long-term.

COMBUSTION SPILLAGE: **Equipment Performance, Technology Trends**

Don Fugler

A) Problem Definition:

1) Envelope air-tightness + stack effect + exhaust flows lead to:

   i) combustion spillage
   ii) high levels of radon entry

2) Open fireplaces and kitchen fans (particularly high capacity kitchen fans) are large exhaust devices, which, may lead to combustion product spillage, especially if operated simultaneously.

3) Natural draft combustion devices begin to exhibit start-up spillage of combustion gases into the living space at about 5 Pa of house depressurization.

4) Intake (make-up air) performance:

   i) There were not enough "purely passive" intakes measured in the recent Duct and Chimney Survey.

   ii) Hard-connected intakes (to return of furnace) yielded an average of about 15 L/s @ 5 Pascals. (ref [1])

5) Poor installation of exhaust devices was found to be a common cause of under-performance of the devices. A common occurrence is the use of 100mm (4") diameter duct for kitchen fans which severely restricts their capacity.

6) Poor performance of some exhaust devices (particularly bath-fans) was attributable to the devices themselves. They did not perform up to their rated capacity in many cases.

7) In B.C., experience is showing that as the quality of exhaust device installation increases, the occurrence of spillage incidents increases.

8) Using analytical prediction from the house air-tightness tests in reference [2], it is possible to predict that 50% of new Canadian homes would experience negative pressure in excess of 5 Pa, if an exhaust flow of 100 L/s were applied.

9) There is a poor relationship between predicted spillage and actual spillage:

i) A theoretical study predicted that 20 to 50% of new houses would have spillage problems.

ii) Actual testing of a large group of all houses showed up to 10% gas-fueld houses showed some spillage and up to 50% of oil-fuelled houses showed some spillage.

Detailed study of those houses which experienced spillage showed that the spillage pattern/incidence was highly variable ranging from "virtually never" to "every firing cycle".

iii) In individual cases, the lack of predictability is evident for example:

House #1: 2 Pa predicted - 8 Pa actual
House #2: 13 Pa predicted - 5 Pa actual

iv) The lack of predictability arises because the actual performance of exhaust devices is variable and un-predictable.

Actual chimney venting performance is also unpredictable, particularly for masonry chimneys

B) With respect to <u>Fireplaces</u>:

1) Recent testing of manufactured fireplaces[3] showed that typical flows range from 25 to 70 L/s. (Flows for manufactured fireplaces are somewhat smaller than for site-built masonry fireplaces.)

2) Findings in reference 3 indicate that the only fireplace intake air systems which match the exhaust flow of the fireplaces were those with fan-forced intake systems.

3) Relying on data from reference 3, it is probable that under certain conditions, fireplace "air intakes" actually exhaust air, due to wind-induced pressure. This is a potential hazard because the intakes are not designed to withstand the high-temperature gas that might be exhausted.

It is possible that arrangements such as cross-ducts for pressure-equalization might relieve this problem, but no field experience is available.

4) In general passive intakes for fireplaces do not match the exhaust flow up the chimney;

   i) In Ontario many individuals in and out of the building industry have been lead to believe to the contrary, owing to the mandation of a 100mm(4") diameter intake in the Ontario Building Code.

   ii) In practice, the air intake would have to be substantially larger than 100mm(4") diameter, and it might not be functional because of wind pressure.

C) Heating Appliances:

1) US energy-efficiency regulations are set to change in 1991 such that only induced draft furnaces will meet the standard. (Except for one furnace which is made by Lennox which could meet the revised AFUE levels without induced draft-this could be a problem)

2) Ontario is matching the progress of US regulation, with a certain time-lag.

3) Continuous depressurization of houses to 10-15 Pa with induced draft appliances does not apparently cause a problem, however depressurization to 20-25 Pa could cause a problem.

   Furnace manufacturers will likely certify their equipment to specific pressure limits in the 10-15 Pa. range.

4) Natural-draft water heaters continue to be available and it is not known whether or not they would be affected by the same process of rising energy-efficiency standards.

5) In Quebec, spillage problems have been identified with bracket (exterior) chimneys. From the modelling and field study work there is no significant mechanism which indicate that bracket chimneys are significantly worse than other chimneys.

D) Conclusions:

1) Close to 1/2 of new houses will face excessive depressurization (if equipped with natural draft devices) and exhaust devices which perform properly.

2) The excessive depressurization referred to above is not predictable and the ability of the chimney to vent is also not predictable.

3) Passive make-up air devices are not capable of meeting exhaust flow requirements and are likely to be blocked by the occupant. Even if open, such inlets result in energy loss.

4) A source of make-up air which can match exhaust flows is required, and which can be activated only when it is required; that is when excessive depressurization would occur.

Such a device is embodied by the stand-alone powered make-up air device which is discussed under Powered Make-up Air Units.

REFERENCES

1. The Canadian Residential Duct and Chimney Survey, CMHC 1989

2. 1989 Survey of the Air-tightness of 200 New Merchant-built Detached Houses; CMHC, IRC, EMR, CHBA

3. Fireplace Air Requirements; CMHC, 1989

POWERED MAKE-UP AIR INLETS: Progress

Don Fugler, Robin Sinha

A) A stand-alone Mechanical make-up air device has been developed under the HTIP Program. The work is based on pressure sensor work by Buchan, Lawton Parent Ltd.

1) First Prototype:

i) was capable of controlling to pressure differentials as low as 4.5 to 5.5 Pascals.

ii) 2-stage control was used with a flow capacity up to 150 L/s

iii) the outside pressure reference for the control signal was obtained via a four-wall pressure-tap arrangement.

2) The second version, a limited production model was produced by Checker manufacturing in Toronto with the following specifications and results:

i) a one-stage heater and control was used; consisting a simple thermostat located in the room into which the unit discharged.

ii) Flow capacity was approximately 80 to 100 L/s.

iii) In field testing, difficulty was experienced in obtaining the correct outside pressure using the four-wall tap system (see discussion below).

iv) In field testing, difficulty was also experienced with on-off cycling times. The developer has suggested that a time-delay cycle is required.

v) In practice the unit cannot be "just installed"; it requires field adjustment with a manometer on start-up to function properly.

vi) Field testing in some instances was quite successful; as an example one house which experienced a negative pressure of 1.5 Pa. with no exhaust devices operating and a 8.5 Pa with all devices operating was controlled consistently by the device to below 5 Pascals. The set-point of the device in this case was set to turn on at 4.5 to 5.5 Pa. and turn off at 2.5 to 3 Pa.

3) With respect to the progress of this device, although there are some minor improvements to be made, it is at a stage where start-up manufacturing can be contemplated.
There is an apparent need and immediate market for such a device.

B) Three manufacturers have been developing three different make-up air/pressure-compensation systems.

1) Dettson manufacturing in Sherbrooke, Quebec has been working on a system with the following features:

i) An adjunct to a forced warm-air heating system, continuous operation of the recirculation blower is required. The air-inlet arrangement consists principally of a mixing box with a motorized, variable-position damper.

ii) Pressure signal is provided by a single pressure control with taps on each of the four house walls.

iii) Exhaust flow is constant, (taken from the recirculation system return air) and make-up air is varied in response to the house-pressure signal. Such a system is referred to as a "pressure-control" type of system.

2) Sheltair Scientific, a consulting company is working on a system with the following features:

i) A single-purpose make-up air unit which uses a hot-water heating coil is used.

ii) all exhaust and intake devices in the house are hard-wired to a single control unit which operates the system so as not to cause pressure imbalance by restricting or allowing various devices. Such a system is referred to as an "interlocked" system.

3) Venmar, a manufacturer from Drummondville, Quebec is working on a system with the following features:

i) An HRV is used as the make-up/exhaust device

and is controlled to regulate pressure.

ii) The type of pressure sensor used consists of small tube with an internal heated thermistor. The sensor calculates pressure from the airflow in the tube, using the known airflow resistance of the tube. The sensors are capable of detecting both positive and negative pressure (airflow).

iii) The system uses four such sensors, one for each side of the house, connected to a central, digital logic unit.

iv) Daniel Forest reported that although there are some problems which have not yet been resolved with respect to the pressure sensor, it is Daniel's personal belief is that the fundamental approach is valid and the developmental problems will be resolved in due course.

v) Venmar has no immediate plans to manufacture the device for sale.

4) The design of the all three systems was based on the requirements of F326 Preliminary and it is recognized that the revised standard is less rigorous with respect to flow.

Even so, achieving flow was not a problem for any of the system developers. Achieving pressure control, or more specifically, obtaining a reliable pressure signal, was the chief difficulty.

i) It is interesting to note that after some experience with the systems, one of the developers that was using a pressure-control type of system reported that they would consider an inter-locked (hard-wired) type of system to be easier.

At the same time, the company that was using an interlocked system concluded that a pressure-control type of system would be easier.

ii) With respect to these types of systems, the field experienced demonstrated that 5 Pascals could be induced by wind and stack effects and was not necessarily attributable only to the operation of exhaust devices.

iii) The attic may be a good location for

pressure-sensors, and may overcome the problems experienced with four-wall types of pressure sensors.

5) Daniel Forest noted that Venmar had previously produced a device called a "Barometric Compensator". The intent of this device was to provide make-up air for devices such as woodstoves. The device was not equipped with a fan and consisted of a wall-sleeve assembly equipped with an inlet, back-flow damper and electric heating element.

Daniel reported that in practice, air would sometimes flow out of the device if it was located on the wrong side of the house with respect to the wind.

Gary Proskiw

A) Air-tightness:

1) House air tightness in Canada ranges between 2 and 8 ACH @ 50 Pascals. The average is 3.4 ACH @ 50 Pa.

2) Theoretical wind air pressures across the envelope can be up to 400 Pa. in a gust.

3) It appears that air-tight house do not deteriorate over time;

   i) This is true for A.D.A. (Air-tight Drywall Approach[1]) houses as well as for houses which use the more conventional polyethylene air-barrier approach.

   ii) There have been no catastrophic failures observed when houses have been checked for air-tightness 3 years after their initial air-tightness testing.

4) Air-sealing technology still has some evolutionary development to be realized.

B) The F326 Ventilation Standard:

1) The new ventilation standard CSA F326, is based on a capacity not a rate.

   This is to say that the standard requires that a system of certain minimum capability be installed but does not mandate that it be operated in a specific way. (see "Occupant Interaction" below)

2) With respect to the requirements in CSA F326 for the distribution of ventilation air within a home;

   i) Forced-warm air type systems are O.K.

   ii) Exhaust-only systems may not be able to meet the distribution requirements if they rely on infiltration or inlet-slots to achieve distribution.

   The standard allows distribution to be achieved by systems which exhaust from all rooms thereby assuring distribution indirectly.

C) Occupant Interaction:

1) A specific observation from close study of homes with a variety of ventilation systems;

i) Homes equipped with HRV-based ventilation systems (intermittent high, continuous low speed) experienced a utilization factor of about 19 hrs/day (79%)

ii) Homes equipped with an equivalent central-exhaust type system (on-off and dehumidistat controlled, single speed) experienced a utilization factor of 37 minutes per day (3%).

iii) Among homes equipped with HRV's there was no difference in utilization between first and second generation HRV's.
The first generation HRV's were noisier, less comfortable, and broke down more often.

2) A conclusion that can be drawn from the above findings is that homeowner education is required, and has been missing in the field of residential ventilation up to this point.
It is surmised that if all occupants were appraised of the negative implications of insufficient ventilation, that they would reverse their habits to a large extent.

D) Pollutants vs Ventilation rate;

i) Continuous ventilation at 0.3 to 0.4 ACH (air changes per hour) controls most measured pollutants.

ii) Formaldehyde shows the best correlation with ventilation rate(i.e formaledehyde levels were shown to be inversely proportional to air change rate).

iii) Radon shows no correlation at all with house ventilation rate

E) Observations/Conclusions:

i) IAQ is significantly better in R-2000 homes than in non R-2000 homes.

ii) Mechanical ventilation is not the answer, but is part of the solution.

F) Costs:

1)	Conventional	$257 (bath & kitchen fans plus fresh air intake)
2)	Central Exhaust	$308 more than conventional
3)	HRV (with forced warm air)	$1200-$1600 more than conventional
4)	HRV (baseboard heating)	$1500-$1600 more than conventional (the price increase over warm-air is due to the cost of additional ductwork to provide distribution).

G) Soil-Gas (Radon):

1) In a recent survey of a mixed group of 40 homes in the Winnipeg area, the following results were recorded.

   i) R-2000 homes . . . 1 pci/L
   ii) New Conventional . 2 pci/L
   iii) Older homes . . . 6 pci/L

   iv) It is surmised that in the above cases, the radon levels are a function of the degree of air-tightness of the below grade elements of the houses.

2) There is a change in the Radon level which is attributable to the change in sign of the pressure difference. This is to say that if the overall house pressure is positive, the radon level will be diminished. If the overall house pressure is negative, the radon level will be increased.
   It is not known whether increasing values of negative pressure result in corresponding increases in radon level.

3) Sub-slab depressurization however, has been demonstrated to effectively "turn-off" radon levels "like flipping a switch", irregardless of house depressurization. This is more true in newer homes which have good integrity of below-grades element such as floor-slabs, walls etc.

4) Little field research exists with respect to the relationship between actual soil gas entry and varying levels of degree of negative pressure.

5) The current limit of continuous negative pressure is set at 10 Pa in F326 because of radon.

Analysis of data from reference 1 does not indicate that 10 Pa would be a problem with current houses, however if higher continuous negative pressures were allowed, more flexibility in designing simple, exhaust-only ventilation systems would be possible.

REFERENCES

1. A.D.A. or Airtight Drywall Approach refers to a house air-tightness approach which involves the use of gaskets at various framing joints and sealant and or gaskets to seal the drywall. The drywall becomes the major constituent element in the air-barrier system.

Protection against vapour-transmission by diffusion is provided by vapour-resistant paint applied to the drywall.

MANDATING VENTILATION: The B.C. Experience

Chris Mattock

A) Process:

1) In 1987 BC adopted the ventilation provisions of the 1985 National Building Code.

2) The present code provisions were developed as a "clarification" of the '85 National requirements

3) Wording was developed; industry meetings were held to discuss the changes and final wording was adopted.

4) Training was carried out and can be considered as the single identifiable factor which contributed to the success of the code changes. The training consisted of;

   i) HRAI-B.C. (British Columbia Chapter of the Heating, Refrigeration and Air-Conditioning Institute) created and ran approximately 50 courses.

   ii) Courses were also provided by CHBA-B.C. for inspectors and builders.

B) With respect to the BC Ventilation Code Provisions themselves;

1) The wording is prescriptive, and is based on charts and tables so that users may simply "look-up" their requirements.
   During development, it became apparent that many users were not willing to carry out the required calculations if arithmetic computation was required.

2) The code is applied to multi-family and apartment occupancies

3) Ventilation:

   i) 0.5 ACH capacity is required in non-distributed (ventilation air to all rooms) systems

   ii) 0.3 ACH capacity is required in distributed systems.

   iii) A portion of the above ventilation capacity must be under the control of a de-humidistat or must be capable of continuous operation.

4) Ratings:

i) Fans which provide the 0.5 and 0.3 ACH are required to be rated at 50 Pa.

ii) Fans which provide continuous or de-humidistat controlled ventilation capability must "low noise" and be rated at or less than 60 dBa or 2-1/2 sones.

iii) The ratings are obtained from manufacturer's published data.

iv) Installed ducts must conform to tables in the code according to airflow, length, and number of fittings, etc.

5) Make-up Air:

i) Make-up air is required in all cases if a natural-draft combustion appliance is installed in the home.

ii) A natural draft appliance does not include induced-draft devices or fireplaces which have tight-fitting, gasketed glass doors and a combustion air inlet directly into the firebox.

iii) No make-up air is required if only sealed or induced draft combustion devices, or non-combustion devices are used.

iv) If natural draft combustion devices are enclosed in an isolated furnace room and provided with separate combustion air, the make-up air requirements do not apply to the house.

Significant field problems have been encountered with these arrangements and they are not recommended. They may be deleted from future code editions.

v) Exhaust devices which are larger than 0.5 ACH must have separate, additional make-up air provided if there are natural draft appliances also present.

Up to 60 L/s make-up may be provided by a passive duct sized according to the relevant table which is based on a maximum 5 Pa. depression.

Over 60 L/s a powered make-up air device must be used with a flow equivalent to that

of the exhaust device and interlocked to operate simultaneously.

Down-draft cook-top manufacturers are now providing wiring connections on their products to facilitate this interlock.

vi) Make-up air tempering is not required in areas where the outdoor winter design temperature is above -10°C (lower mainland and lower vancouver island)

In these areas the make-up may consist of open duct into boiler/furnace room area, heated crawlspace, or to behind the refrigerator. (Ducts to behind the refrigerator have not been entirely successful).

A duct directly into the return air plenum of a forced-warm air system is also accepted.

vii) In areas colder than -10°C, a pre-heater is required if the duct is not to a Forced-Warm Air system.

If the duct is to a Forced Warm Air system, it must have a motorized damper and be interlocked with the furnace fan and the de-humidistat of other device. (installed cost about $200). The duct dia. is normally about 4" and of all the "code minimum" systems, this seems to work the best.

viii) An on-site spillage test is allowed as an option to verify if make-up air is <u>actually required</u>.

At least one municipality is conducting these tests on a regular basis.

6) Supply-only ventilation systems are allowed.

C) <u>Conclusions</u> drawn from B.C. Experience:

1) Ventilation Equipment Installers must be trained and certified to ensure systems complying with code requirements are installed.

2) Building inspectors must be trained and required to pass a qualifying exam. They should understand both performance and prescriptive code compliance.

3) CGSB 51-71[1] should be finalized and made a recognized standard so that it can be referenced in the [Building] code for flue gas spillage testing.

4) Ventilation air distribution to bedrooms in houses with non-forced-air heating systems should be required. Moisture and IAQ (indoor air quality) problems have been noted in B.C. code homes with base-board [and radiant] heating.

5) Less sophisticated low cost [ventilation] systems can bring penalties of poor comfort, (drafts, cold air pooling on floor), higher fuel use, and in non-forced-air systems, moisture problems.

6) Placing naturally aspirated furnaces in isolated furnace rooms to avoid ventilation and range hood make-up air requirements can cause a series of other problems:

   i) Depressurization of furnace room in crawlspace homes

   ii) Compromising continuity of air-barrier.

   iii) Icing of flues

   iv) High fuel consumption

7) Tables and/or simple field tests are required for effective implementation of new standards.

D) The Future;

1) B.C. will adopt most likely adopt the provisions of F326 when they become part of the NBC in '95.
   The present requirements are viewed as an interim measure until F326 is available. (F326 was not complete at the time of drafting of the present requirements).

2) Upcoming changes will probably require that distribution of ventilation air be effected to all bedrooms.

REFERENCES

1. Field Test for Spillage of Flue Gases from Combustion Appliances, CGSB Draft Standard 51-71

A) With respect to present practice;

1) There are no ventilation requirements which are enforced by building inspections personnel (even though some requirements may exist in the building code ['85 NBC])

2) Range hoods and bath fans are installed in perhaps 90% of all new residential construction.

3) Central, non-heat-recovery ventilation systems are installed in perhaps 30 % of new homes <u>in addition</u> to the bath and kitchen fans referred to above.

4) There is a distinct lack of qualified installers. This is thought to arise because of a lack of HVAC trades in the residential sector, which is dominated by baseboard electric heating.

5) There is a good level of awareness among consumers that relates lack of ventilation to poor indoor air quality and in particular to the occurrence of condensation on windows.

B) With respect to <u>Heating Systems</u>;

1) In Quebec, the predominant heating fuel is electricity (over 90%), which leads to an absence of heating appliance combustion spillage events.

2) There are only two residential natural gas distribution networks; one in Montreal, the other in Sherbrooke.

3) There continues to be a healthy level of "Gas go boom" reporting in the media. Spectacular incidents may have some relationship to the age of the gas system and connected appliances (in Montreal).

4) Hydro Quebec now offers subsidies for "dual energy" systems:

i) Such systems heat primarily with electricity, but switch to another fuel such as oil or propane when the outdoor temperature is below -12°C.

ii) The incentive consists of a reduction in base Kwh cost to the homeowner from $0.045 to $0.028 per kWh. The homeowner can expect to save $200-$300 per year.

iii) This is leading to a shift away from base-board type heating systems to forced warm air type heating systems.

C) With respect to Make-up Air:

1) The difficulties which arise due to lack of make-up air are in the majority linked to the existence of a fireplace.

2) Fireplaces are seen as diminishing in numbers of new-home penetration, however they remain a significant number (greater than 10%).

3) The % of woodstove installation is not known.

4) Recently, the City of Montreal placed a moratorium on the installation of fireplaces and woodstoves for air pollution reasons.

5) Make-up air heating will become an issue because of the lack of forced-warm air heating systems.

A) With respect to Building Codes;

1) The Ontario building code has been updated to the specifications of the 1990 National Building code with respect to ventilation. i.e.; 0.3 ACH, no distribution requirements.
Previous to this, there were no residential ventilation requirements save for when a window opening was not located in a washroom or kitchen.

2) There has not been any change in the enforcement pattern of building officials, however, so that from the point of view of the builder, there has not been a change in the code.

3) There is no consensus as to what the code changes actually mean.

4) A probable result is that fans will now be installed in all washrooms (they are not currently, see below).
It is not anticipated the building inspectors will inspect for potential spillage.

5) The industry does not expect major change in ventilation requirements until 1995.

6) There is a large variation with respect to actual enforcement, even within cities; for example, the gas inspector and building inspector disagree with respect to the requirement for a combustion air inlet.

B) With respect to Present Practice:

1) Air-sealing practice consist generally of running the poly behind electrical boxes and taping and foaming around windows.
Builders are raising their level of practice, but inspection has not changed.

2) Most heating systems in southern Ontario are forced air gas.

3) In areas where gas is not available Ontario Hydro gives a one-time grant of $2,000 if:

i) the house is R-2000

ii) a ground-source heat-pump is installed. (Ground-source heat-pump installations run around $12,000 and have C.O.P's of about 2.5)

4) There is a reliance on HVAC contractors for the design of the heating systems and this is enforced in major municipalities where the contractor is required to submit a heating design in order to obtain a "heating permit".

The reliance on the HVAC contractor for design expertise extends to ventilation systems in as much as it concerns those ventilation systems which are above and beyond the "basic" kitchen and bath fan arrangements. There is no approval process in place for ventilation system designs.

5) For "basic" systems, the electrician provides, installs and wires-up the ventilation fixtures such as bath and kitchen fans. The HVAC contractor provides the ductwork only.

Only for non-basic ventilation systems such as those with HRV's does the mechanical contractor provide the full ventilation system including appliance. Even in these cases, the kitchen fan is normally provided by the electrical contractor.

6) From the HVAC contractor's point of view, heating systems are designed because if the customer is cold, there will be a complaint.

Ventilation devices are not viewed as source of complaints, therefore less design effort is expended.

7) New-home construction may be defined for the purposes of this discussion into two sectors:

i) "Spec" or Basic construction (most new homes)
ii) Custom construction (smaller #'s but higher value)

8) For Basic Construction:

i) Most heating systems are naturally aspirated, only about 5-8% are mid efficiency. High-efficiency appliances are not installed.

ii) Ventilation systems consist of:
-bath fan (about 100% in Ottawa area and less in Toronto) (a)kitchen fan (about 60% in Ottawa and less in Toronto).

iii) Fans are installed with:
-bath: 3" duct
-kitchen: 4" duct

iv) Some homes in this sector are equipped with HRV-based ventilation systems but this occurs when the purchaser engages the mechanical contractor directly to do the work.

v) Complaints of condensation and moisture problems are not common in this sector.

vi) Builders and HVAC Contractors will only do what is required of them by local inspectors.

9) For Custom Construction:

i) High-efficiency heating systems are the norm.

ii) 75% of the market uses central, HRV-based ventilation systems.

iii) Complaints arising from excess moisture and condensation do occur in this market. Consumers are generally more aware and expectations are higher. Builders are aware of the problem and solutions (install ventilation).

10) The following Opinions are offered:

i) Only the mandation of improved ventilation will increase the present levels of "improved" ventilation system installation.

ii) It remains to be seen whether any meaningful change will occur in present practice due to the most recent code changes; if any change does occur, it will be because of enforcement, not because of the fact of change of the code itself.

iii) HRV systems exceed the present code, are "non-threatening" to the mechanical contractor and are a method of adding value in high-end work.

iv) HRV systems appear to be "threatening" to builders at the present time.

A) Present Practice;

1) Bath & kitchen fans are installed in most new homes.

2) The city of Winnipeg mandates a 5" dia fresh air intake but this is not enforced. It is scheduled to begin to be enforced next year.
There has been concern expressed by MHBA that the proposed make-up air intake will not remain open due to occupant intervention.

3) There is no enforcement of any particular ventilation requirements.

4) Most houses are very tight, running around 2.0 ACH @ 50 Pa.

5) A sealed poly air-vapour-barrier (acoustic sealant all joints, staples) is the norm in new construction.

6) Natural draft furnaces and water heaters are the norm.

7) There is some awareness of IAQ in the public's mind, principally with respect to moisture (and Radon depending on CBC's programming schedule).

8) About 20% of new homes (mostly all high-end) are equipped with fire-places.

9) High-efficiency combustion devices are only found in high-end construction.

10) All new home have triple glazing.

11) Heating fuel is predominantly gas in urban areas and predominantly electric in rural areas.

12) Heating systems are designed by the mechanical contractor

13) Ventilation systems are not designed, they are installed.

A) Present Practice:

1) Ventilation air is supplied by a 4, 5 or 6 inch duct connected from outside to the return air plenum of the furnace. This arrangement provides about 20 L/s of outdoor air when the furnace is running.

2) Air-sealing of conventional houses is fairly good, with an average of 2.5 air changes per hour at 50 Pascals according to the 1989 survey[1]. Using the divide by 20 rule[2], the houses only get about 0.1 air changes per hour naturally.

3) The largest home-builder in the province, (Cairns) uses a central exhaust fan connected to the bathrooms and kitchen. If run continuously, the fan does give adequate ventilation though at an energy cost penalty.

4) There is some awareness of the problems with formaldehyde, with many of the better informed builders avoiding particleboard indoors.

5) A few houses have been built for the ultra-sensitive, with mixed results because of a poor selection of materials in some cases.

6) The space heating system of choice is Forced Warm Air Natural Gas; Natural Draft Chimney (natural gas is only 1.2 cents/kWh)

7) Combustion air intakes of 5 or 6" dia.; insulated with a U-bend are enforced on new installations.

8) Many ventilation systems consist of central exhaust fans connected to the bath and kitchen.

9) There is some public awareness of formaldehyde as an IAQ issue. (One large builder does not use particle board).

10) There is some low-tox construction, but there is a lack of information.

11) Higher fractions of HRV-based ventilation systems are found in custom homes only along with mid and high efficiency heating systems.

12) HRV's and higher efficiency heating systems are generally not found in "spec" or Basic home construction.

B) One major concern Regarding CSA F326:

1) Energy Costs; Electrical costs to run fan(s) particularly a central warm air furnace fan running continuously, will be significantly higher.

i) At 6 cents per Kwh, the annual cost of running a standard 1/4 hp Electrical motor is $203[3]. If the fan was previously considered to run about 1/4 of the year; then additional cost to the home-owner would be in the order of $150.

ii) This additional cost may be mitigated by converting to an PSC electric motor which is marginally more expensive and consumes 1/2 the energy. Additional electrical costs would be about $50/year to the occupant.

iii) Even higher efficiency electric motors are expected to be available; such as DC-electronically commutated ones.

REFERENCES

1. 1989 Survey of the airtightness of 200 Merchant Built Homes

2. A crude approximation of the average rate of natural air change during the heating season that might be expected in a house in the absence of mechanical ventilation. The air-changes at 50 Pascals is divided by 20; for example if Air-changes @ 50= 5 then expected natural air-change would be 0.25.
For a more detailed examination of the relationship between measured air-change and expected natural air-change, the reader is referred to reference 1.

3. Assumes 3,380 kwh/year on 24 hr, 365 day year (8,760 hours) for a 1/4 hp motor using 386 Watts.

A) Present Practice:

1) Spec homes have natural draft appliances

2) There is a higher penetration of sealed combustion type heating equipment in the Custom Home market.

3) The Custom Home market is sensitive to ventilation

4) The Spec Home market is not sensitive to ventilation and only installs code-minimum equipment.

5) Highwall diffusion systems for the heating system is used by some builders (mostly high-end) with good success. It is not significantly more expensive than a conventional forced-warm-air layout.

B) Industry/Consumer attitudes:

1) There is a solid niche market for firms which sell and install ventilation systems (usually HRV-based) and high-efficiency heating equipment.
These firms are active in the custom-home sector of the market.

2) There has been some success in selling the value of ventilation, and this has come mostly from the efforts in the R-2000/Quality plus efforts;
There is an increasing general awareness of the benefits of ventilation.

3) There has been a shift towards only one or two bath fans because they are the only ones which meet the noise requirements.
There is a recognition that major manufacturers of this equipment provide reliable data, but that some other's may not.

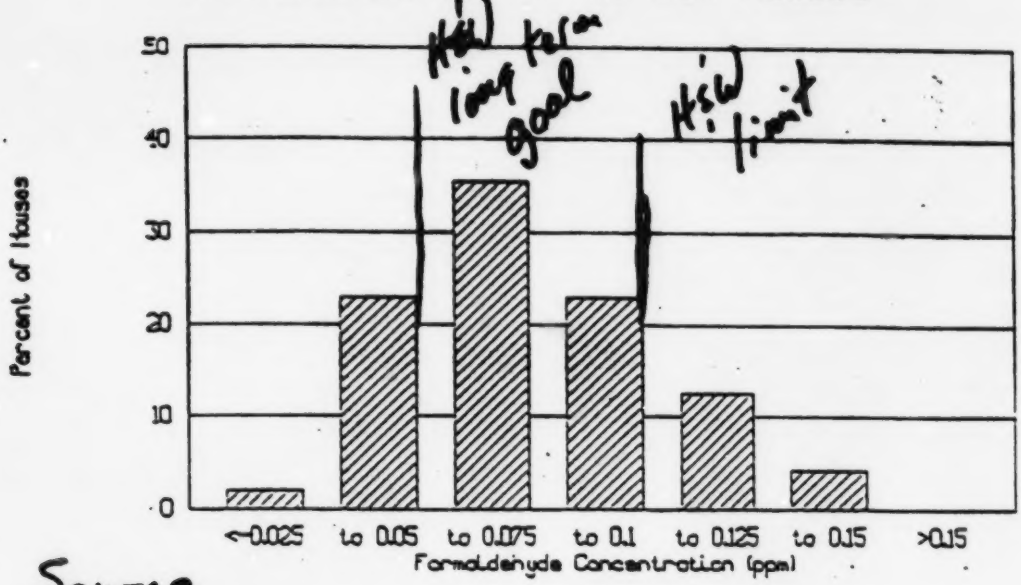
C) Other:

1) The observed shift to forced warm-air (particularly on Vancouver Island) is as much a product of the recent and/or expected arrival of natural gas service, and not necessarily caused by the change in ventilation requirements. (Although the ventilation change has some effect, due to reduced cost for make-up air if a forced-warm air system exists.)

APPENDIX A

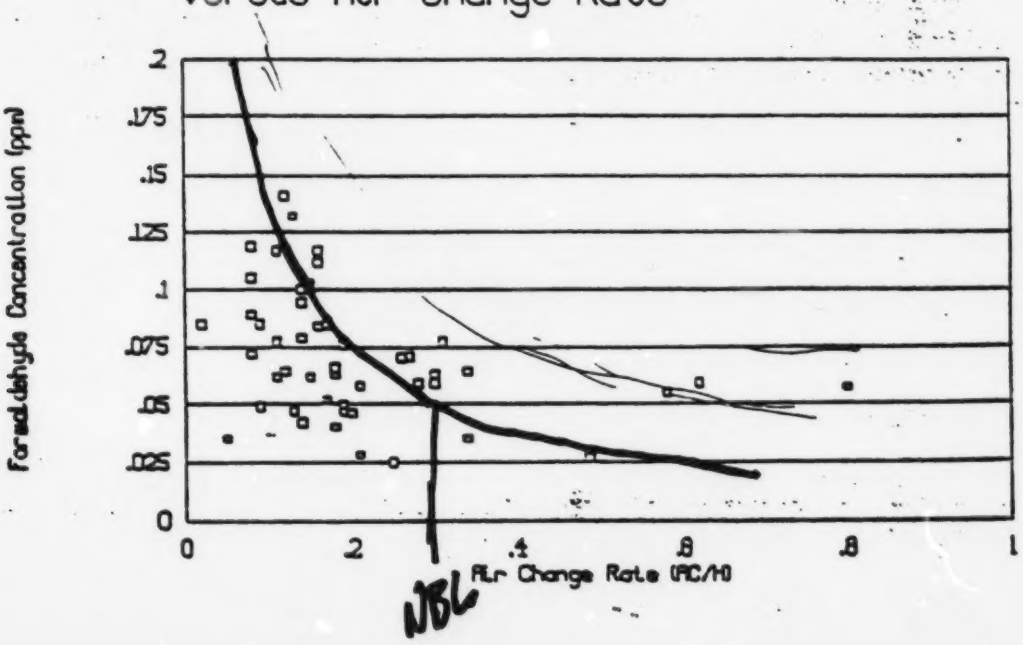
SPEAKERS NOTES

Fig.7 Distribution of Formaldehyde Concentrations in 48 New Houses



$C_{inc.} = \frac{\text{Source}}{\text{Ventilation}}$

Fig.8 Formaldehyde Concentration versus Air Change Rate



Source: Ventilation and Air Tightness - Tom Hamlin, CMHC, 1990

SOME OBSERVATIONS
REGARDING
INDOOR AIR QUALITY
IN
NEW CANADIAN DETACHED HOUSES

1. The 1989 Airtightness survey indicated that passive ventilation would not be adequate for most new houses in Canada.

2. The R-2000 results indicate that properly installed ventilation systems can do the job of controlling indoor air quality in almost all new houses. However, avoiding known emitting materials such as particle boards is also strongly advised.

3. Hypersensitive individuals need houses that have even lower air pollution levels than even the R-2000.

4. There is virtually no quantitative information of practical value available on the offgassing levels of common building building materials. (e.g. particle board, paints, flooring materials, gypsum board, wall paper, concrete additives, interior grade plywood)

R. Dumont

CURRENT VENTILATION, AIRSEALING, AND COMBUSTION AIR MAKEUP REQUIREMENTS IN SASKATCHEWAN

VENTILATION IS SUPPLIED PASSIVELY BY A 5 OR 6 INCH DUCT CONNECTED FROM OUTSIDE TO THE RETURN AIR PLENUM OF THE FURNACE

AIRSEALING OF CONVENTIONAL HOUSES IS RELATIVELY GOOD, WITH AN AVERAGE OF 2.5 AIR CHANGES/H AT 50 PASCALS ACCORDING TO THE 1989 SURVEY. USING THE DIVIDE BY 20 RULE, THE HOUSES ONLY GET ABOUT 0.1 AIR CHANGES PER HOUR NATURALLY.

THE LARGEST HOUSEBUILDER IN THE PROVINCE (CAIRNS) USES A CENTRAL EXHAUST FAN CONNECTED TO THE BATHROOMS AND KITCHEN. IF RUN CONTINUOUSLY, THE FAN DOES GIVE ADEQUATE VENTILATION THOUGH AT AN ENERGY COST PENALTY. *

THERE IS SOME AWARENESS OF THE PROBLEMS WITH FORMALDEHYDE, WITH MANY OF THE BETTER INFORMED BUILDERS AVOIDING PARTICLE BOARD USE INDOORS.

A FEW HOUSES HAVE BEEN BUILT FOR THE ULTRA-SENSITIVE, WITH MIXED RESULTS BECAUSE OF A POOR SELECTION OF MATERIALS IN SOME CASES.

SPACE HEATING SYSTEM OF CHOICE:
FORCED WARM AIR NATURAL GAS HEAT,
NATURAL DRAFT CHIMNEY (NATURAL GAS IS ONLY 1.2 CENTS/KWH)

COMBUSTION AIR SUPPLIED BY AN INSULATED 5 OR 6 INCH DIAMETER DUCT WITH A U-BEND

ONE MAJOR OUTSTANDING

CONCERN REGARDING

CSA F326

ENERGY COSTS

ELECTRICAL ENERGY COST TO RUN FAN(S).
PARTICULARLY A CENTRAL WARM AIR
FURNACE FAN RUNNING CONTINUOUSLY.

AT 6 CENTS PER KWH, THE ANNUAL COST
OF RUNNING A STANDARD 1/4 HP ELECTRICAL
MOTOR IS $203.

VENTILATION TASK FORCE - RECOMMENDATIONS

October 16, 1990

PREPARED BY GARY PROSKIW, P.Eng., UNIES Ltd.

1. Develop house Δp controllers.
2. Develop low cost, low maintenance, self-balancing HRV's and ventilation systems.
3. Develop novel ventilation systems.
4. Develop simple, low cost methods for field evaluation of ventilation compliance.
5. Develop make-up air devices for single and multi-family residences.
6. Develop high mixing efficiency/low pressure drop diffusers.
7. Develop a portable system for measuring ventilation effectiveness and compliance.
8. Study the relationship between house Δp and radon/soil gas entry.
9. Study occupant satisfaction and IAQ.
10. Develop protocols for field measurements of ventilation system performance.
11. Develop product rating standards for high pollutant source building products.
12. Develop techniques for increasing ventilation effectiveness.
13. Develop affordable low pollutant housing guideline for sensitive (not hypersensitive) individuals.

CHRIS MATTOCK

Conclusions Drawn From B.C. Experience

- Ventilation equipment installers must be trained and certified to ensure systems complying w/ code requirements are installed
- Building inspectors must be trained and required to pass a qualifying exam. They should understand both performance and prescriptive code compliance.
- CGSB 5171 should be finalized and made a recognized standard so that it can be referenced in the code for flue gas spillage testing.
- Ventilation air distribution to bedrooms in houses with non f.a. heat systems should be required. Moisture and IAQ problems noted in B.C. Code homes w/ base board heating.

- Less sophisticated low cost systems can bring penalties of poor comfort (drafts, cold air pooling on floor), higher fuel use and in nat. f.a. systems moisture problems.

- Placing naturally aspirated furnaces in isolated furnace rooms to avoid ventilation and range hood make up air requirements could cause a series of other problems.

  - Depressurization of furnace room in crawlspace homes
  - Compromising continuity of the air barrier
  - Icing of flues
  - High Fuel Consumption

SUBSECTION 9.33.3. MECHANICAL VENTILATION

(See Appendix A.)

Mechanical ventilation requirements

9.33.3.1. Except as required in Article 9.33.3.2., *dwelling units* shall have a mechanical ventilation system capable of providing, during the heating season, at least 0.5 air change per hour or according to Table 9.33.3.A.

9.33.3.2. Mechanical ventilation systems in *dwelling units* designed in accordance to Part 6 to distribute ventilation air to or from all habitable rooms, but excluding such rooms as storage, foyer, laundry or mechanical rooms, shall be capable of providing, during the heating season, not less than 0.3 air change per hour or according to Table 9.33.3.A.

9.33.3.3. The rate of air change in Articles 9.33.3.1. and 9.33.3.2., and Table 9.33.3.A shall be based on the total interior volume of all *storeys* including the *basement* and heated crawl spaces, but excluding any attached or built-in garage.

Table 9.33.3.A.
Forming Part of Articles 9.33.3.1. and 9.33.3.2.

MINIMUM REQUIRED VENTILATION RATE			
Max. Total Interior Volume[1], m^3	Max. Total Floor Area[1] Based On Standard 2.44 m Ceiling Height, m^2	Minimum Ventilation Rate	
		0.5 Air Change per Hour, L/s	0.3 Air Change per Hour, L/s
122	50	17	10
146	60	20	12
171	70	24	14
195	80	27	16
220	90	31	18
244	100	34	20
366	150	51	31
488	200	68	41
610	250	85	51
732	300	102	61
975	400	137	82
1219	500	171	102
1463	600	205	123
Column 1	2	3	4

Notes to Table 9.33.3.A.:

(1) For rooms or spaces to be included or excluded see Article 9.33.3.3.

B.C. BUILDING CODE 1985
FIRST REVISIONS
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Rooms or spaces without natural ventilation

9.33.3.4. Where a habitable room or space in a *dwelling unit* is not provided with natural ventilation described in Article 9.33.1.5., mechanical ventilation shall be provided to that room or space that is capable of providing 0.5 air change per hour if the room or space is mechanically cooled in summer, and 1.0 air change per hour if it is not.
(See Appendix A.)

Automatic or continuous operation

9.33.3.5. A portion of the ventilation rate required by Articles 9.33.3.1. and 9.33.3.2. shall be controlled automatically by a centrally located dehumidistat, or be provided by a continuously operating fan during the heating season. This portion of ventilation rate shall conform to Table 9.33.3.B. (See Appendix A.)

Table 9.33.3.B.
Forming Part of 9.33.3.5.

MINIMUM REQUIRED VENTILATION RATE CONTROLLED AUTOMATICALLY OR PROVIDED CONTINUOUSLY			
Max. Total Interior Volume[1], m^3	Max. Total Floor Area[1] Based On Standard 2.44 m Ceiling Height, m^2	Minimum Ventilation Rate, Controlled Automatically, L/s	Minimum Ventilation Rate, Provided Continuously, L/s
244	100	20	10
366	150	30	15
488	200	40	20
732	300	40	30
975 and over	400 and over	40	40
Column 1	2	3	4

Notes to Table 9.33.3.A.:

(1) For rooms or spaces to be included or excluded see Article 9.33.3.3.

9.33.3.6. Except as provided for in Subsection 9.33.4. or as otherwise stated in this Subsection, mechanical ventilation shall conform to the requirements of Part 6.

Make-up Air

9.33.3.7. Except as provided in Articles 9.33.3.8. and 9.33.3.14., mechanical ventilation systems for *dwelling units* shall include provision for introduction of fresh make-up air from the exterior for the ventilation rate controlled automatically or provided continuously as described in Article 9.33.3.5.

Make-up Air not required

9.33.3.8. Make-up air as described in Articles 9.33.3.7. and 9.33.3.13. is not required, if the *dwelling unit* does not contain a naturally-aspirating fuel-fired heating *appliance*, or if all fuel-fired *appliances* are isolated from the *dwelling unit* atmosphere. *Acceptable appliances* include induced draft or sealed *furnaces*, gas fireplaces and hot water tanks, with combustion air directly from outside and with sealed *flues*, or fireplaces and *space heaters* that are equipped with tight-fitting, gasketed doors with all air supply requirements directly from the outside into the firebox.

Make-up Air tempered

9.33.3.9. Make-up air shall be tempered as described in Articles 9.33.3.10. to 9.33.3.12.

9.33.3.10. For locations with winter design temperature not less than -10°C make-up air may be tempered by being supplied by ducting into secondary areas such as utility or storage rooms, by specially designed individual room or space through-wall diffusers, by methods described in Article 9.33.3.11., or by other *acceptable* methods.

9.33.3.11. For locations with winter design temperature less than -10° C make-up air may be tempered by being supplied through a forced air heating system as described in Article 9.33.3.12., by heating/fan unit, by heat recovery ventilator, or by other *acceptable* methods.

Make-up Air tempered by forced-air heating systems

9.33.3.12. Make-up air tempered through forced-air heating systems shall be provided by a duct connected to the return-air *plenum*. The make-up air duct shall be at least 100 mm diam or an equivalent combined duct with the furnace air supply. The make up air duct shall be provided with a motorized damper that is interlocked with the exhaust fan controlled by the dehumidistat so that the exhaust fan only operates when the damper is in the open position. The dehumidistat shall also be interlocked with the furnace air circulating fan so that the furnace fan will operate when the exhaust fan is on and the damper is open.
(See Example (c) in A-9.33.3.)

B.C. BUILDING CODE 1985
FIRST REVISIONS
SEPTEMBER 1988

Make-up air for other exhaust appliances

9.33.3.13. Except as described in Article 9.33.3.8., additional separate make-up air for the entire capacity shall be provided for other exhaust *appliances* installed in the *dwelling unit* with a rated exhaust capacity exceeding 0.5 air change per hour, or according to Table 9.33.3.A. Non-forced make-up air shall conform to Table 9.33.4.4. for the rates indicated, otherwise the make-up air shall be provided by a fan-forced unit of equivalent capacity interlocked with the exhaust appliance.

Combination forced air/ ventilation sytem

9.33.3.14. A naturally-aspirating forced air heating system serving a maximum total heated floor area of 460 m^2 is *acceptable* as providing the ventilation requirements, if the system is capable of providing at least 0.3 air changes per hour during its heating operation or has an air supply according to Table 9.33.3.C. The system shall have a ventilation rate controlled automatically or provided continuously by the furnace air circulating fan as required by Article 9.33.3.5., and have the required air supply according to Table 9.33.3.C., provided directly to the return-air *plenum*.
(See Example (b) in A-9.33.3.)

Table 9.33.3.C.
Forming Part of 9.33.3.14.

MINIMUM AIR SUPPLY DUCT[1] DIAMETER FOR A COMBINATION FORCED AIR/VENTILATION SYSTEM		
Max. Total Interior Volume[2], m^3	Max.Total Floor Area[2] Based On Standard 2.44 m Ceiling Height, m^2	Minimum Air Supply Duct[1] Diameter, mm
536	220	100
805	330	125
1122	460	150
Column 1	2	3

Notes to Table 9.33.3.C.:

(1) The air supply duct has been sized for one duct to provide both for the air supply as required by the furnace installation code and for the ventilation air required by this Subsection.

(2) For rooms or spaces to be included or excluded see Article 9.33.3.3.

9.33.3.15. Special purpose air exhausting equipment such as central vacuum cleaning systems, downdraft cook tops and clothes dryers shall not be included in calculating the capacity of the ventilation system.

9.33.3.16. Systems designed to provide combustion and/or dilution air for fuel-burning *appliances* shall not be used to supply make-up air for the ventilation systems unless their capacity is sufficient to serve both functions simultaneously. An *acceptable* combination system includes a forced air heating system as described in Article 9.33.3.14.

Sound rating

9.33.3.17. Wall and ceiling fans required by Article 9.33.3.5. to be controlled automatically or operate continuously, shall be rated by the manufacturer not to exceed a sound level of 60 dBA or 2.5 Sones.

Exhaust ducts

9.33.3.18. *Exhaust ducts* shall discharge directly to the outdoors. Where the *exhaust duct* passes through or is adjacent to unheated space, the duct shall be insulated to prevent moisture condensation in the duct.

Access to ventilation equipment

9.33.3.19. Ventilation equipment shall be accessible for inspection, maintenance, repair and cleaning. Except where the kitchen exhaust grille is located at least 1.2 m horizontally from the range, kitchen *exhaust ducts* shall be designed and installed so that the entire duct can be cleaned where the duct is not equipped with a filter at the intake end.

Air intake shield

9.33.3.20. Outdoor air intake and exhaust outlets shall be shielded from weather and insects. Shielding from insects for ventilating equipment may be by an accessible filter at the equipment and by a 6 mm mesh screen at the intake or exhaust hood. Screening if used shall be of rust-proof material.

Duct requirements

9.33.3.21. Ventilating ducts shall conform to the requirements of Part 6 for *supply ducts*, except *exhaust ducts* that serve only a bathroom or water-closet room may be of *combustible* material provided the duct is reasonably air tight and constructed of a material impervious to water.

Doors undercut

9.33.3.22. Interior doors for dwelling units shall be undercut a minimum of 12 mm or the rooms shall be provided with a grille of an equivalent area.

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SUBSECTION 9.33.4. BASIC MECHANICAL VENTILATION SYSTEM

(See Appendix A and Example (a) in A-9.33.4.)

General

9.33.4.1. A basic mechanical ventilation system shall comply with the requirements in Article 9.33.3.1. and shall consist of one or more exhaust fans, without an air circulating ductwork system. The exhaust fans shall be located in some or all of the kitchens and bathrooms. The ventilation system shall conform to the appropriate requirements of Subsection 9.33.3., except the system need not conform to Part 6.

Exhaust fan

9.33.4.2. The exhaust fans required in Article 9.33.4.1. shall be rated for sound as required in Article 9.33.3.17. and controlled automatically by a dehumidistat as required in Article 9.33.3.5.

System capacity

9.33.4.3. The mechanical ventilation capacity of the exhaust fans in Article 9.33.4.1. shall be assumed as the total of the individual fans, rated by the manufacturer at a differential pressure of at least 50 Pa. The exhaust duct size shall conform to Table 9.33.4.A.

Table 9.33.4.A.
Forming Part of Article 9.33.4.3.

EXHAUST DUCT[1] SIZE FOR A BASIC VENTILATION SYSTEM IN SUBSECTION 9.33.4.		
Maximum Exhaust Fan Ventilation Rate, L/s	Min. Exhaust Duct[1] Dia,	
	Smooth Duct	Flexible Duct
10	75	100
25	100	125
45	125	150
70	150	175
Column 1	2	3

Notes to Table 9.33.4.A.:

[1] The exhaust ducts shall not exceed 15 m in length or have more than two 90° elbows, otherwise the duct shall be increased to the next diameter size.

Make-up air

9.33.4.4. Make-up air shall be provided for the ventilation rate controlled automatically or provided continuously as described in Article 9.33.3.5. and shall conform with Articles 9.33.3.7. to 9.33.3.11. The non-forced air opening size for make-up air for a basic ventilation system as provided for in this Subsection shall conform to Table 9.33.4.B. Forced make-up air equipment shall be rated by the manufacturer to provide for the required air flow rate.

Table 9.33.4.B.
Forming Part of Article 9.33.4.B.

MAKE-UP AIR OPENING SIZE FOR A BASIC VENTILATION SYSTEM IN SUBSECTION 9.33.4.		
Maximum Ventilation Rate Controlled Automatically or Provided Continuously, L/s	Mimimum Make-up Air Duct	
	Vent Area, cm^2	Diam, mm
8	47	80
12	66	90
15	85	100
17	95	110
20	114	120
25	142	130
30	170	150
35	199	160
40	227	170
45	255	180
50	284	190
55	312	200
60	340	210
Column 1	2	3

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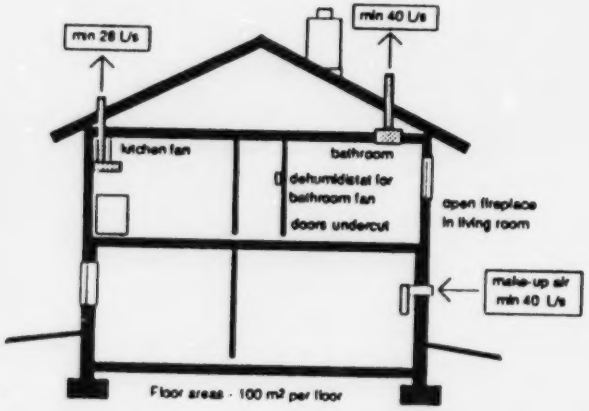
	Page	Reference	Revision
•	400	9.34.1.7.	In the fourth line change: "0.018 m^2" to "100 mm diam or equivalent area".
•	403	9.35.1.5. & 9.35.1.6.	Add new Articles: **9.35.1.5.** Except as required in Article 9.35.1.6., electrical wiring and cables installed in *buildings* permitted to be of *combustible construction* shall conform to Sentence 3.1.4.1.(3). **9.35.1.6.** Where a concealed space in a floor or ceiling assembly is used as a *plenum*, electrical wiring and cables within the *plenum* shall conform to Clause 3.5.4.3.(1)(a).
	457	Appendix A	Add new note: **A-3.1.4.1.(3)(d)(i)** The term raceway is defined in CSA C22.1, "Canadian Electrical Code, Part 1" and includes both rigid and flexible conduit.
•	492	Appendix A	Add new Note: **A-9.6.6.4. Hinge and Strikeplate Fastening.** When hinges and strikeplates are installed they must fasten into solid wood. Screws should be sufficiently long to either pass through a thin door jamb, cross a shimmed back space and penetrate at least 25 mm into structural framing or, in the case of a door with a sidelight where the mullion may be the structural component, penetrate at least 25 mm into the mullion.

Page	Reference	Revision
492	Appendix A	**A-9.7.2.1. Windows.** The CSA Standard CAN3-A440, "Windows", includes a window classification system that rates the assembly according to air leakage, water leakage and wind load resistance. the ratings, shown below, are marked on the window and indicate the level of performance that can be expected. Units can then be selected which are most appropriate for the design conditions. **Air Leakage** A1-intended for use primarily in low-rise residential (i.e. building of 3 storeys or less and having an area not exceeding 600 m^2), industrial, and light commercial use. A2-intended for use primarily in medium-to high-rise residential, institutional, and commercial use. A3-intended for use in high-performance institutional and commercial applications. **Water Leakage** B1-moderate climatic conditions B2-severe climatic conditions B3-extreme climatic conditions **Wind Resistance** C1-lowest wind load resistance C2-medium wind load resistance C3-highest wind load resistance Article 9.7.2.1. has specified the lowest grades since the NBC is a collection of minimum requirements only. Designers or builders may wish to consider windows with higher ratings depending on the height of buildings, climatic conditions and occupancy classification.

Page	Reference	Revision
501	Appendix A	Delete all existing Appendix Notes t Subsection 9.33.3. and substitute th following: **A-9.33.3. & A-9.33.4. Mechanica Ventilation.** Subsection 9.33.3. contain the general requirements for mechanica ventilation systems for dwelling units. I also references Part 6 for the design of th ventilation systems, except for the "Basi Mechanical Ventilation System" described i Subsection 9.33.4. Part 6 in turn require good engineering practice, such as found i ASHRAE handbooks and HRAI Digest for th design of ventilation systems. Subsection 9.33.4. "Basic Mechanica Ventilation System", contains the specifi requirements for the installation an verification of a simple ventilation system utilizing exhaust fans and make-up air a required. The following examples illustrate differen ventilation systems and how the requirement can be satisfied depending on the heatin system used. The house used in thes examples has two storeys with 100 m^2 pe floor and contains an open fireplace.

Example (a): shows the Basic Mechanical Ventilation System as described in Subsection 9.33.4., this can be used with any heating system. For this example the following would apply:

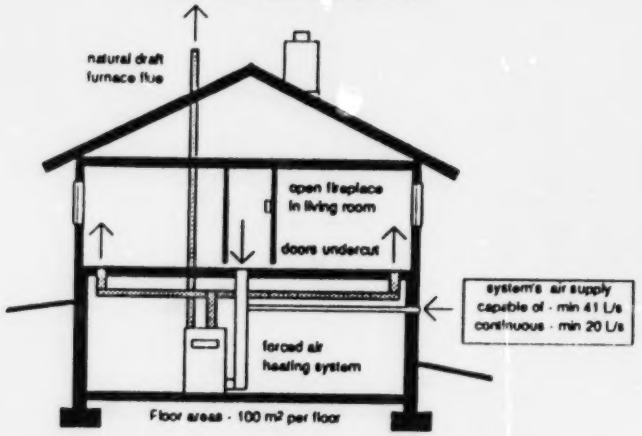
1. 9.33.4.1. - 0.5 air changes per hour or from Table 9.33.3.A. for 200 m^2 a minimum ventilation rate of 68 L/s is required, this is provided by kitchen and bathroom exhaust fans;
2. 9.33.4.2. - the bathroom fan to be rated for a maximum sound rating of 60 dBA (2.5 sones), be controlled by a dehumidistat and from Table 9.33.3.B. a minimum ventilation rate of 40 L/s is required;
3. 9.33.4.3. - fans to be rated at a minimum of 50 Pa, exhaust duct size according to Table 9.33.4.A.;
4. 9.33.4.4. - make-up air is required since there is an open fireplace; from Table 9.33.4.A. a 170 mm diameter duct is required for the 40 L/s bathroom fan and in this case it is provided to a storage room in the basement; and
5. 9.33.3.22. - doors to be undercut a minimum of 12 mm or a grille of an equivalent area provided.



(a) BASIC MECHANICAL VENTILATION SYSTEM - 0.5 A.C./H. WITH ANY HEATING SYSTEM

Example (b): shows a ventilation system utilizing a naturally-aspirating forced air heating system with a two-speed furnace fan as described in Article 9.33.3.14. A permitted alternate arrangement could utilize a dehumidistat which would control the furnace air circulating fan for the ventilation rate as required by Article 9.33.3.5. This is a combination heating/ventilating system where the furnace provides the heating as well as supplying the required house ventilation air. In this example, one air supply duct is provided to the return air plenum to provide both for the air supply as required by the furnace installation code and for the ventilation air required by Subsection 9.33.3. For this example the following would apply:

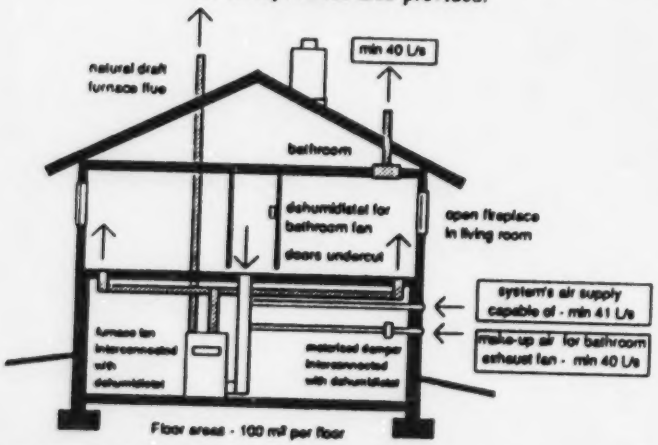
1. 9.33.3.14. - 0.3 air changes per hour or from Table 9.33.3.A. for 200 m^2 total heated floor area a minimum ventilation rate of 41 L/s is required;
2. 9.33.3.14. - minimum continuous ventilation rate of 20 L/s from Table 9.33.3.B. provided by the two-speed furnace fan;
3. 9.33.3.14. - the furnace and ventilation outdoor air supply provided by a 100 mm diameter duct directly to the return-air plenum from Table 9.33.3.C.;
4. 9.33.3.2. - the system design to Part 6, which also refers to ASHRAE handbooks and HRAI Digest for design of ventilation systems; and
5. 9.33.3.22. - doors to be undercut a minimum of 12 mm or a grille of an equivalent area provided.


natural draft furnace flue
open fireplace in living room
doors undercut
system's air supply capable of - min 41 L/s continuous - min 20 L/s
forced air heating system
Floor areas - 100 m2 per floor

(b) VENTILATION SYSTEM WITH A FUEL-FIRED FORCED AIR HEATING SYTEM - 0.3 A.C./H. AND CONTINUOUS VENTILATION

Example (c): shows a ventilation system utilizing a naturally-aspirating fuel-fired forced air heating system with a single speed furnace fan and a bathroom exhaust fan. In this example, an additional 100 mm make-up air duct with a motorized damper is provided to the return-air plenum for the make-up air required by the bathroom exhaust fan. This additional make-up air could also be provided by increasing the furnace air supply duct and installing a two-position motorized damper. For this example the following would apply:

1. 9.33.3.2. - 0.3 air changes per hour or from Table 9.33.3.A. for 200 m^2 total heated floor area a minimum ventilation rate of 41 L/s is required;
2. 9.33.3.5. - minimum ventilation rate controlled automatically of 40 L/s from Table 9.33.3.B., provided by bathroom exhaust fan;
3. 9.33.3.12. - make-up air is required since there is an open fireplace, this can be supplied through the forced air heating system by a separate 100 mm duct with a motorized interlocked damper as described in Article 9.33.3.12;
4. 9.33.3.2. - the system design to Part 6, which also refers to ASHRAE handbooks and HRAI Digest for design of ventilation systems; and
5. 9.33.3.22. - doors to be undercut a minimum of 12 mm or a grille of an equivalent area provided.


natural draft furnace flue
min 40 L/s
bathroom
dehumidistat for bathroom fan
doors undercut
open fireplace in living room
system's air supply capable of - min 41 L/s
make-up air for bathroom exhaust fan - min 40 L/s
furnace fan interconnected with dehumidistat
motorized damper interconnected with dehumidistat
Floor areas - 100 m² per floor

(c) VENTILATION SYSTEM WITH A FUEL-FIRED FORCED AIR HEATING SYTEM - 0.3 A.C./H. AND BATHROOM EXHAUST FAN

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	Page	Reference	Revision
•	501	Appendix A	Add new Note: **A-9.33.3.4.** A mechanical ventilation system capable of operating on a year round basis is required for habitable rooms or spaces which do not have openable windows. The ventilation system for these rooms may be combined with the whole house ventilation system described in Articles 9.33.3.1. and 9.33.3.2. In most cases to comply with this requirement, an exhaust fan controlled by a switch or dehumidistat capable of providing 1 air change per hour (where summer cooling is not provided) based on the room or space volume would be required.
•	501	Appendix A	Add new Note: **A-9.33.3.5. Automatic Control.** This Article requires that the fan(s) of a required ventilation rate be controlled automatically by a centrally located dehumidistat. In a typical example, where the bathroom exhaust fan(s) are controlled by this centrally located dehumidistat, the exhaust fan(s) should also be controlled by a switch or timer located in the bathroom. In all cases the centrally located dehumidistat would be the overriding switch. For the most effective use of the dehumidistat, it is recommended that the setting be between 40% to 60% relative humidity to maintain a healthy environment and to control any potential moisture problems.

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	Page	Reference	Revision
*	501	Appendix A	**A-9.33.3.7. Make-up air.** Make-up air is not required for the entire ventilation capacity only for the ventilation rate controlled automatically or provided continuously. However, in Article 9.33.3.13. additional separate make-up air is also required for any exhaust appliance with a capacity exceeding 0.5 air change per hour. This acknowledges the fact that although houses are being built tighter there is still enough air leakage through the envelope that can provide the additional air requirements of approximately 50L/s to 100L/s at 5 Pa, depending on the size of the house. This is based on a leakage rate or NLA of 1.08 cm^2/m^2 as established by a BETT/EMR survey of airtightness of housing across Canada. The 5 Pa depressurization has been established as the maximum permitted depressurization to prevent backdrafting of naturally-aspirating appliances.

| - indicates N.R.C. errata (issued January 1988)
*- indicates B.C. errata

Note: N.R.C. issued revisions (or errata) do not automatically become part of the B.C. Building Code, they must be adopted by the Province.

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